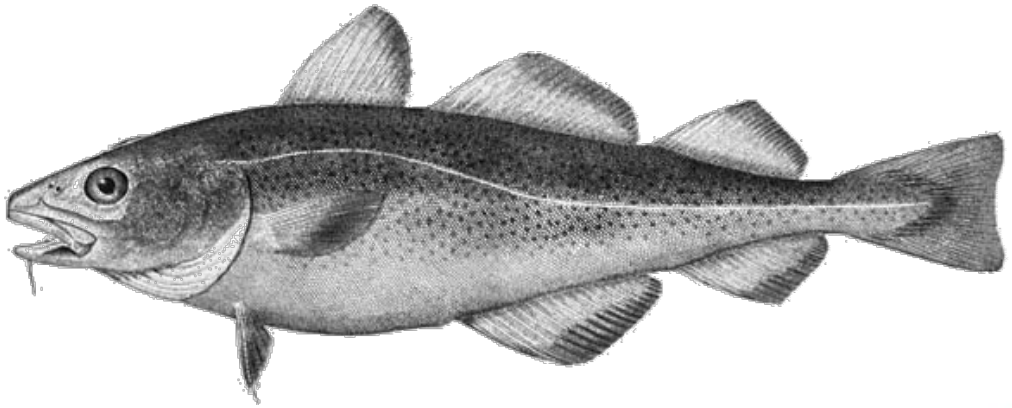
Gulf of Maine Atlantic cod

Assessment summary

NOAA FISHERIES

NEFSC



SSC Meeting
October 25, 2021

Review: 2019 Assessment Update

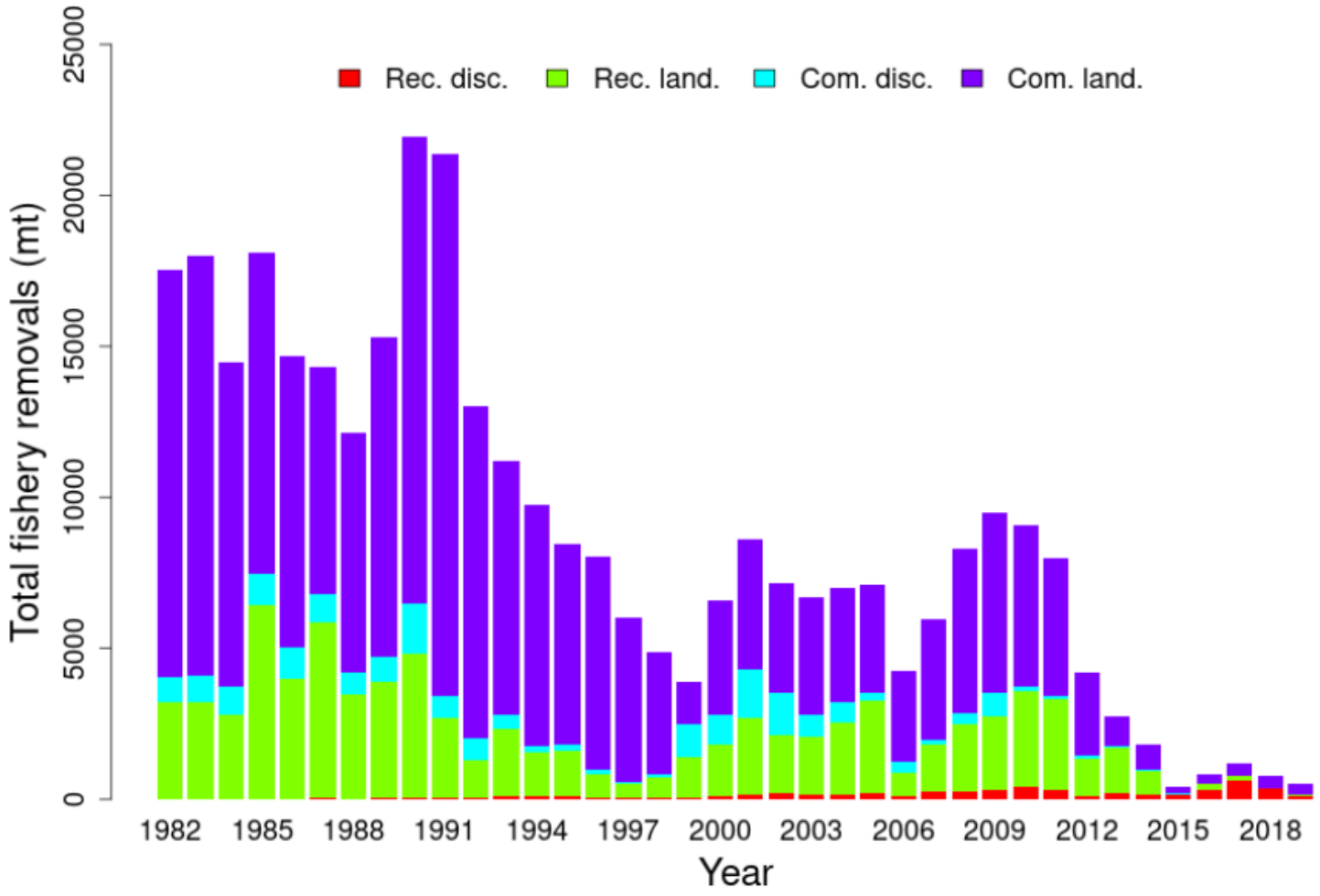
- Stock Status

Assessment	Proxy reference points	M=0.2	M-ramp
2019 update	$F_{full,\ 2018}$	0.188 (0.113 - 0.263)	0.198 (0.124 - 0.273)
	F_{MSY}	0.173	0.175
	$F_{full,\ 2018}/F_{MSY}$	1.09	1.13
	Overfishing	Yes	Yes
	SSB_{2018} (mt)	3,752 (2,432 - 5,071)	3,838 (2,582 - 5,094)
	SSB_{MSY} (mt)	42,692 (27,916 - 62,785)	63,867 (46,144 - 84,098)
	SSB_{2018}/SSB_{MSY}	0.09	0.06
	Overfished	Yes	Yes
	MSY (mt)	7,580 (4,853 - 11,366)	11,420 (8,149 - 15,268)
	Median age1 recruitment (000s)	4,677 (1,064 - 16,392)	9,249 (2,129 - 18,031)

- Issues and uncertainties:
  - Two accepted models (M=0.2, M-ramp), overall uncertainty in current natural mortality
  - Both the M=0.2 model exhibited major retrospective pattern, M-ramp had minor retrospective pattern
  - Continued low recruitment compromises rebuilding potential of the stock

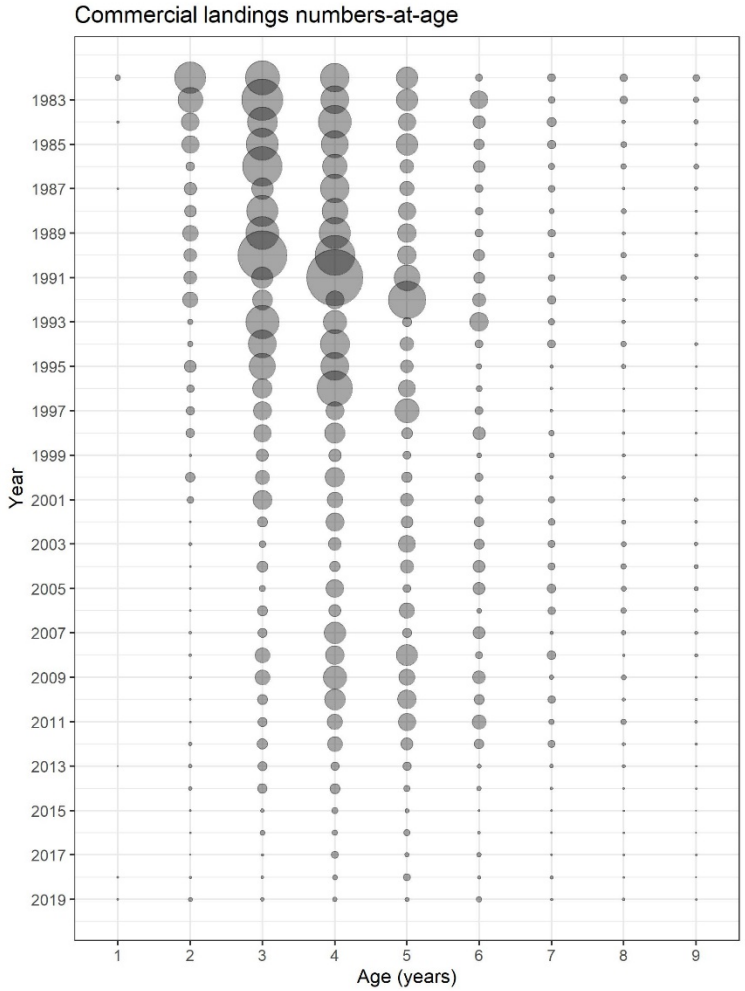
Overview of Fishery Data

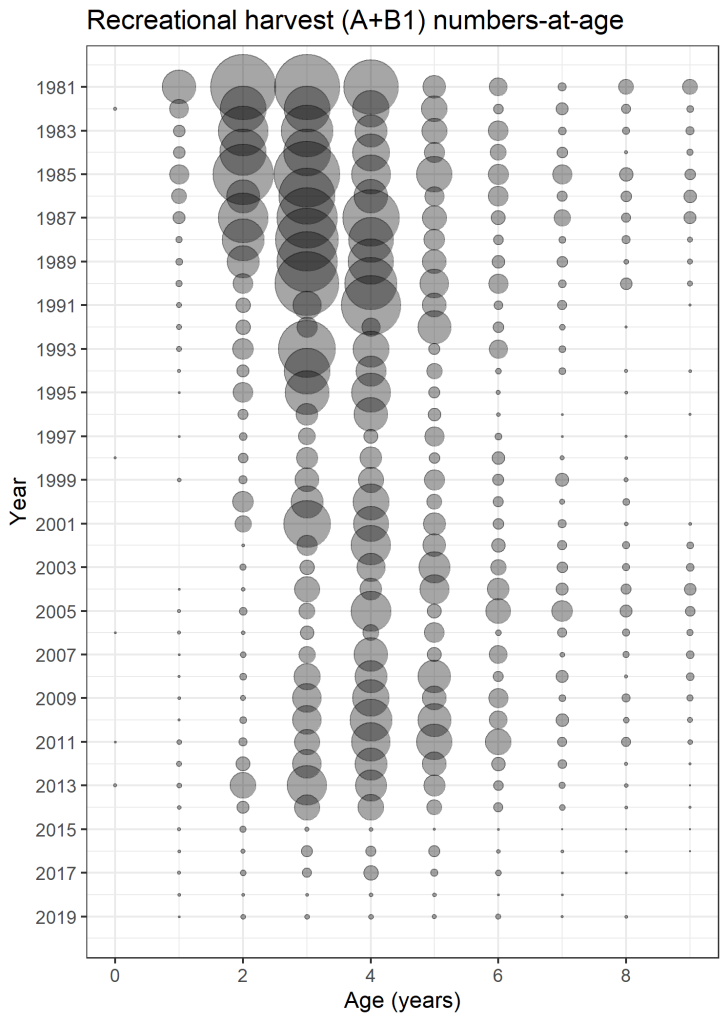
- Fishery: catch source



Overview of Fishery Data

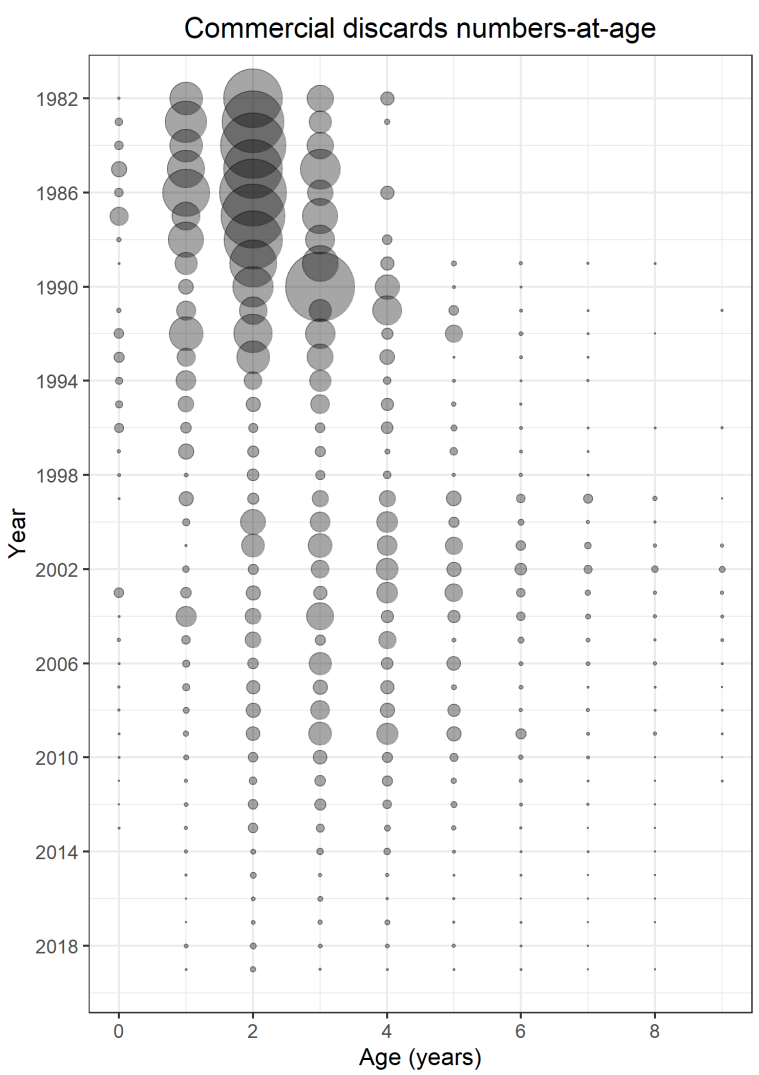
- Fishery: commercial and recreational age structure (landings):

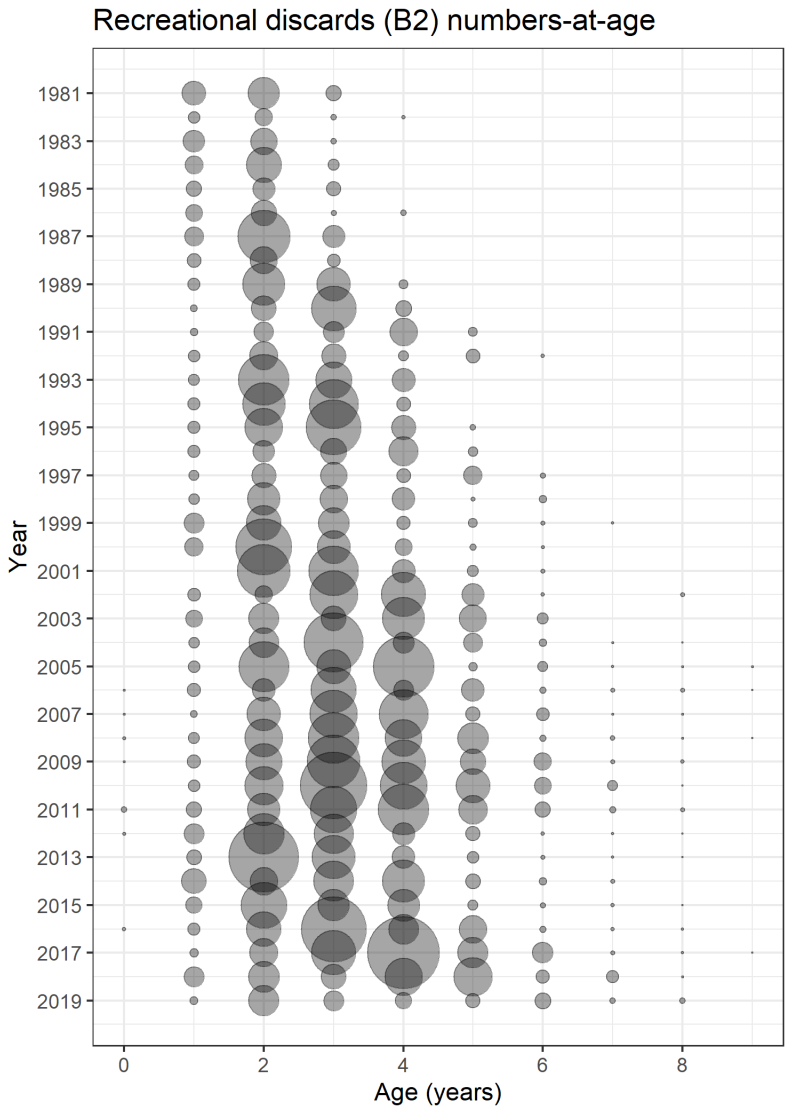




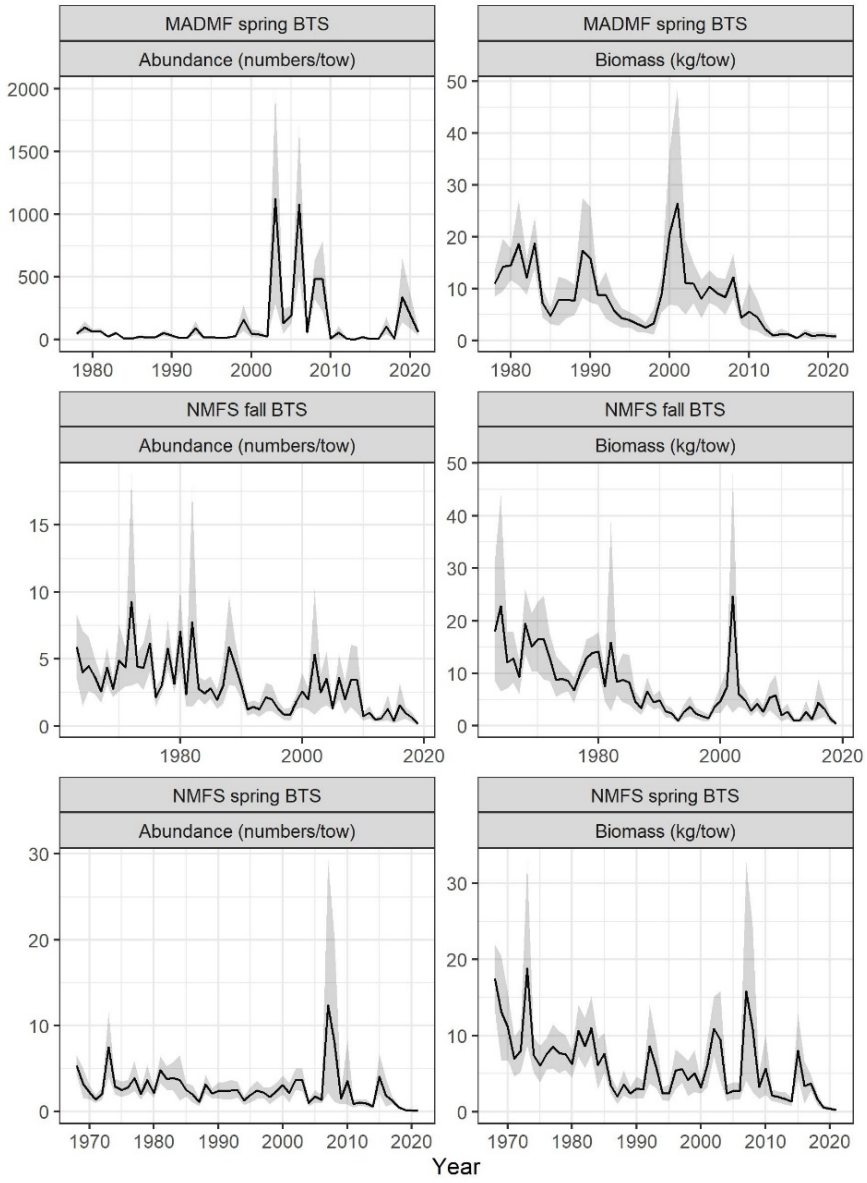
Overview of Fishery Data

- Fishery: commercial and recreational age structure (discards):

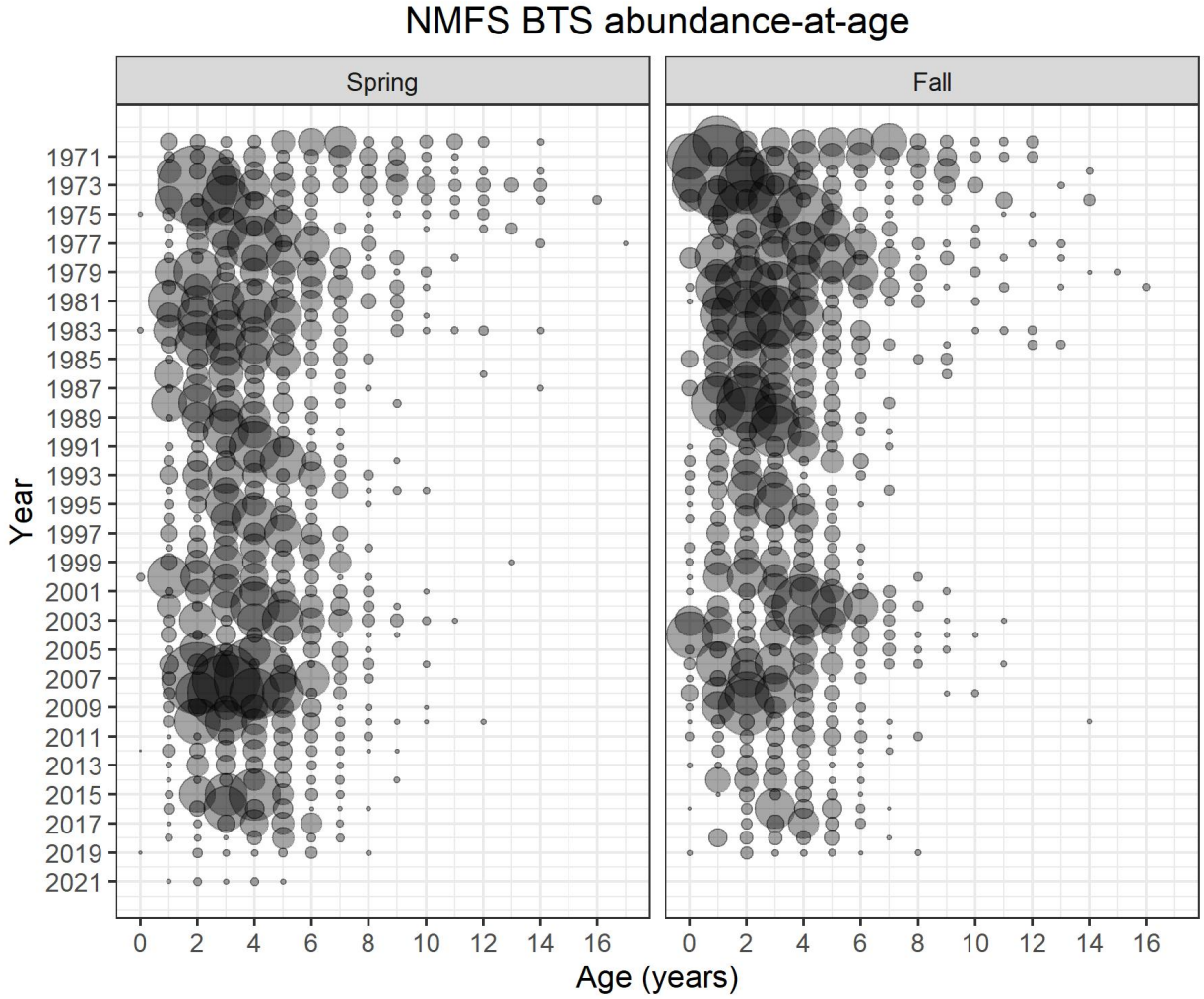




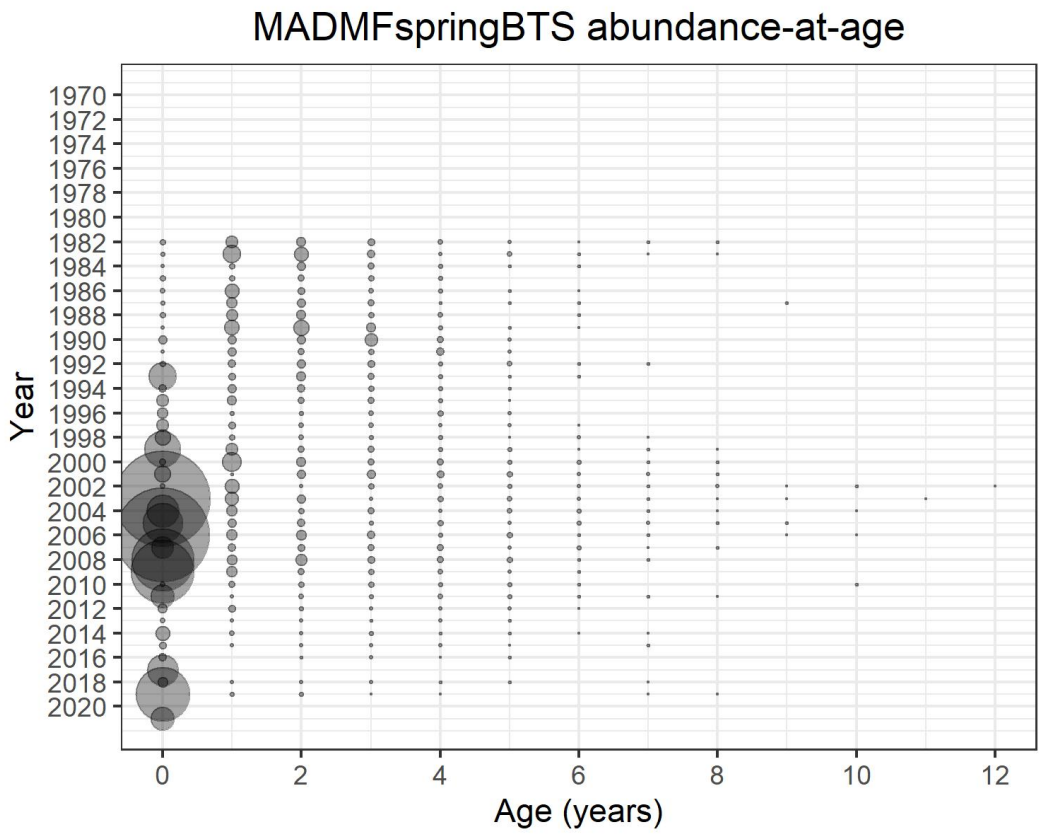
Overview of Survey Data



Overview of Fishery and Survey Data

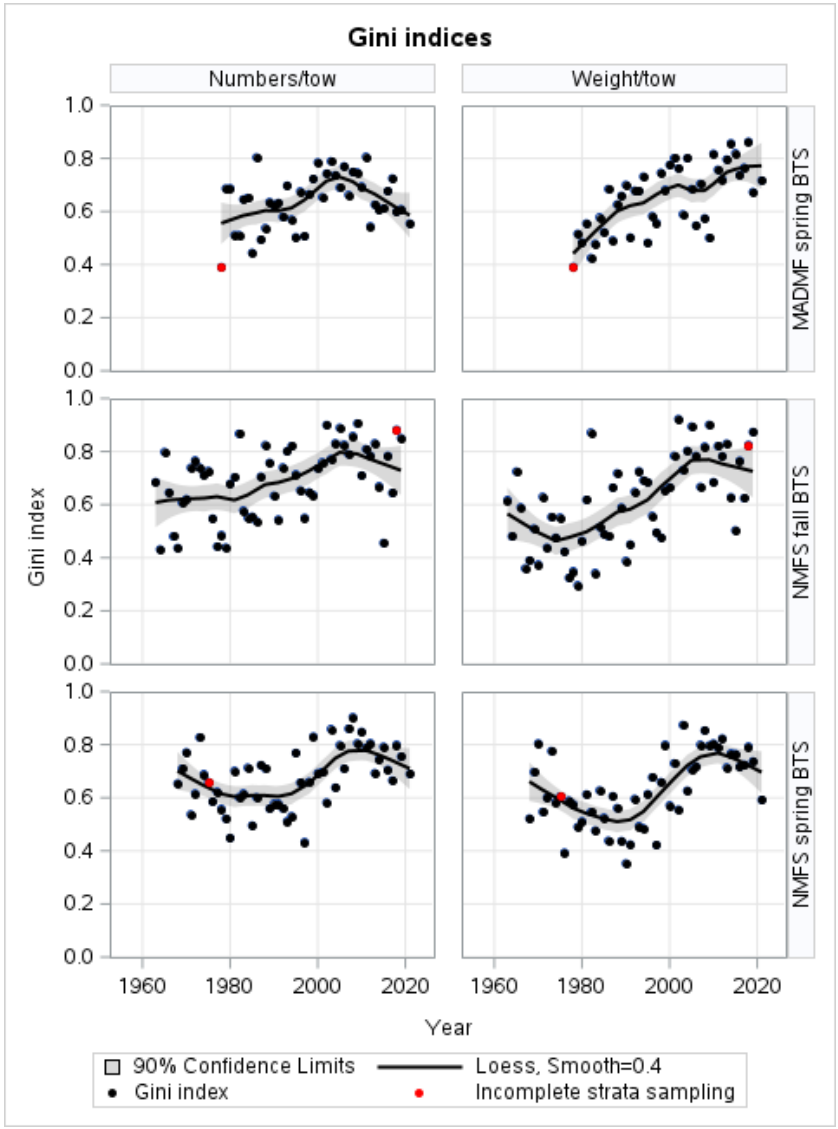


Overview of Fishery and Survey Data



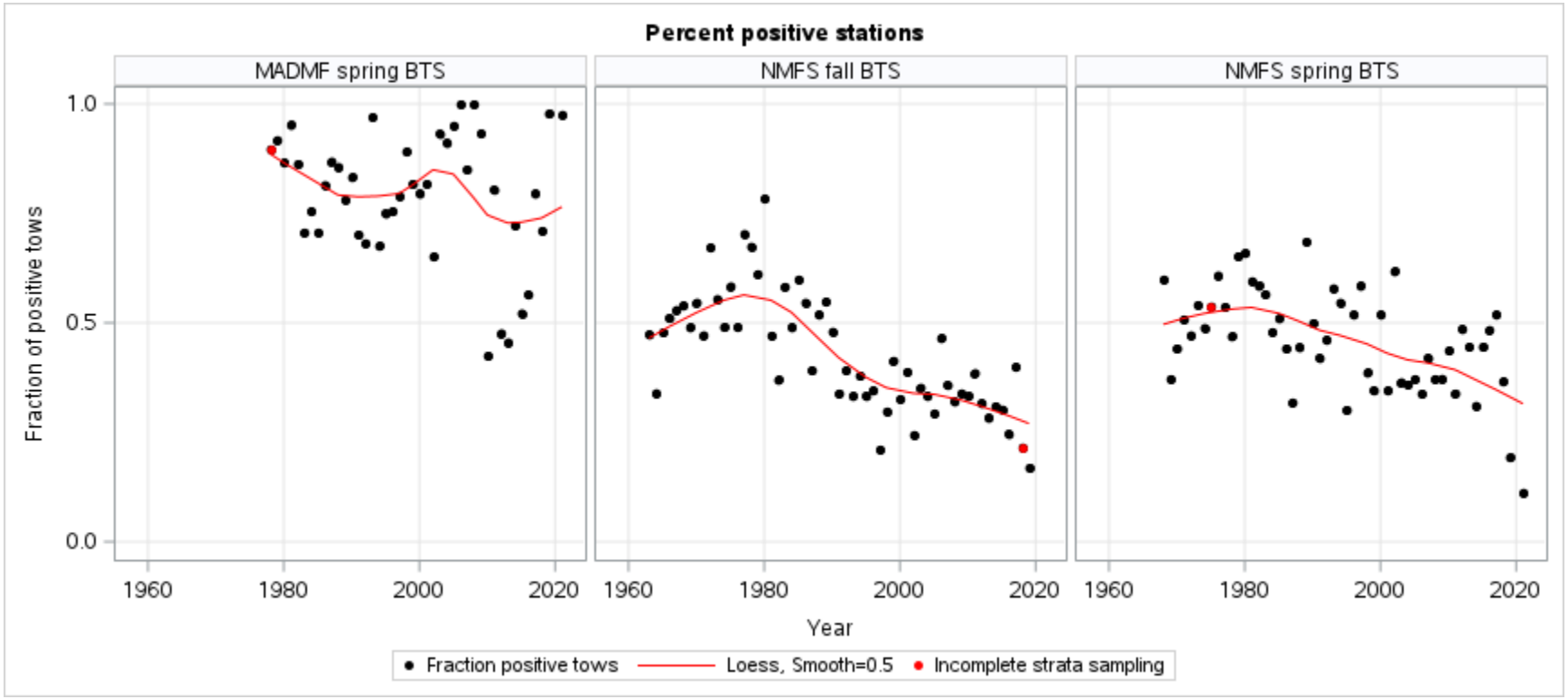
Overview of Fishery and Survey Data

- Survey: spatial distribution



Overview of Fishery and Survey Data

- Survey: spatial distribution



2021 Assessment Update Overview

- Incorporate one additional year of data (2019) into the assessment time series
- Update the SAW/SARC 55 ASAP models through 2019
- Update F_{MSY} proxies ($F_{40\%}$)
  - Use recent 3-year average weights
- Update SSB_{MSY} proxies
- Update short-term projections (2022-2024)

Model Inputs

- Biology
  - Maturity-at-age (1982-2019 time series average)
  - Natural mortality differs across models (M=0.2 or M-ramp from 0.2→0.4)
  - Stock weights-at-age using the Rivard approach

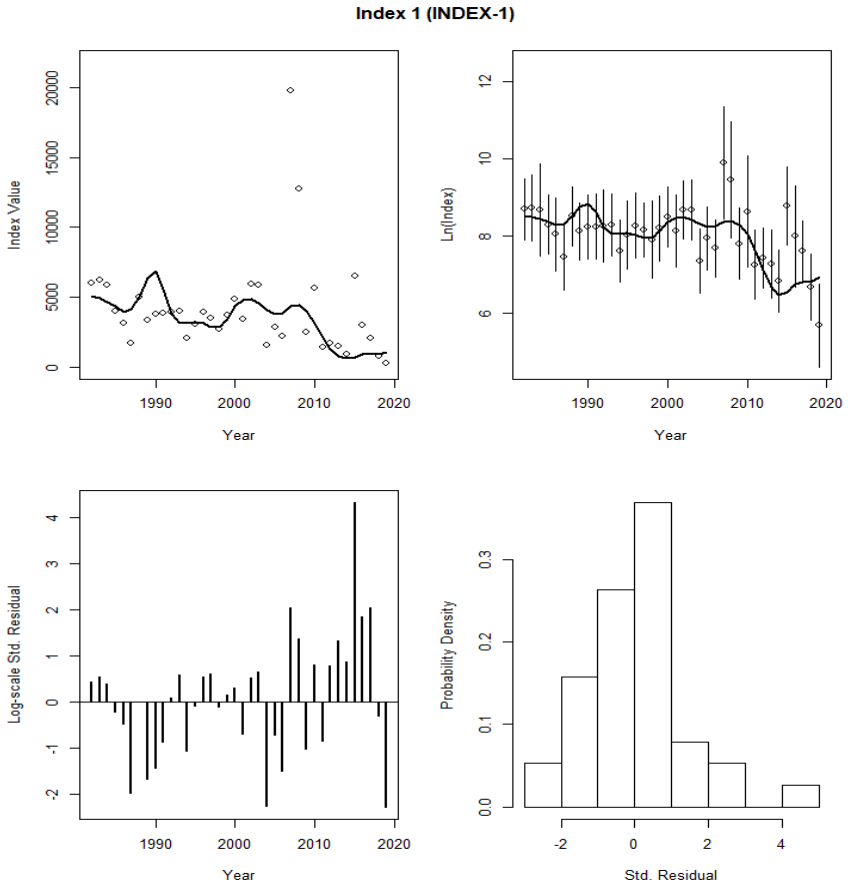
- Fishery removals
  - Commercial landings and discards (ages 1-9^{+})
    - Discard mortality rate varies by gear
  - Recreational landings and discards (ages 1-9^{+})
    - Discard mortality rate = 15%
  - Catch weights-at-age

- Surveys
  - NEFSC spring and fall (ages 1-9^{+})
  - MADMF spring (ages 1-6)

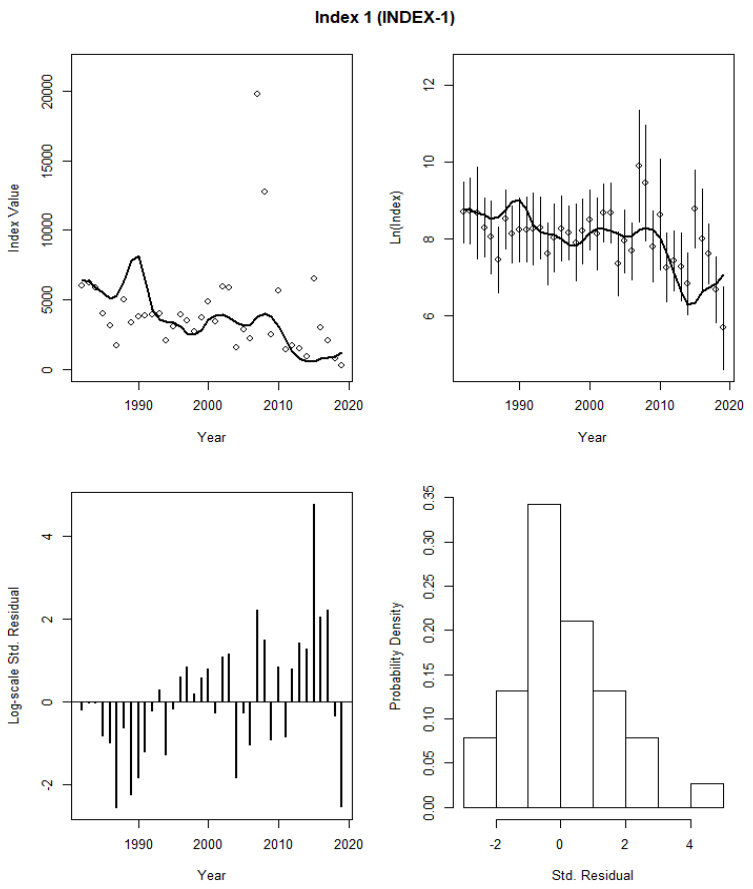
Model Diagnostics

- Model fits survey indices (Spring NMFS)

M=0.2



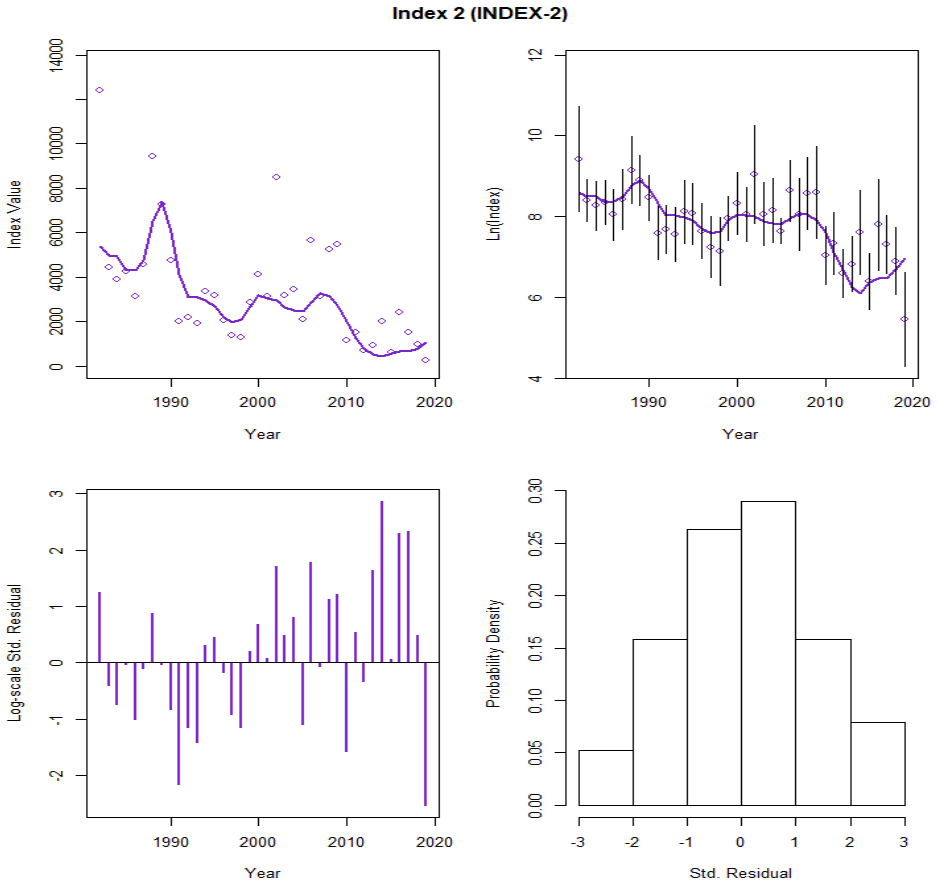
M-ramp



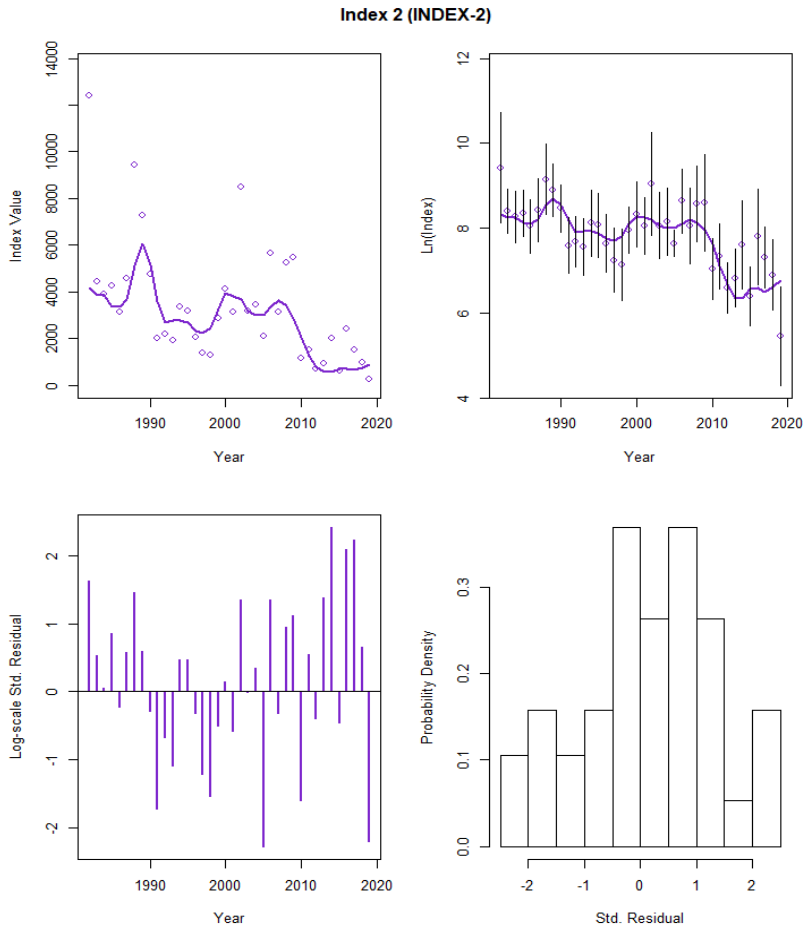
Model Diagnostics

- Model fits survey indices (Fall NMFS)

M=0.2



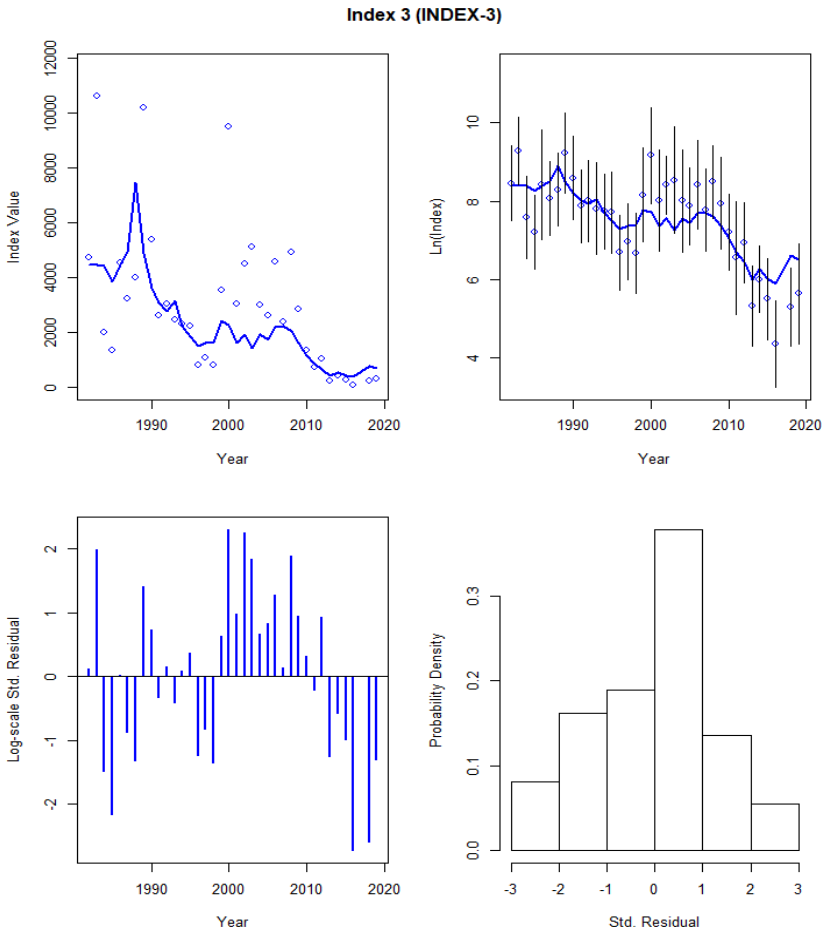
M-ramp



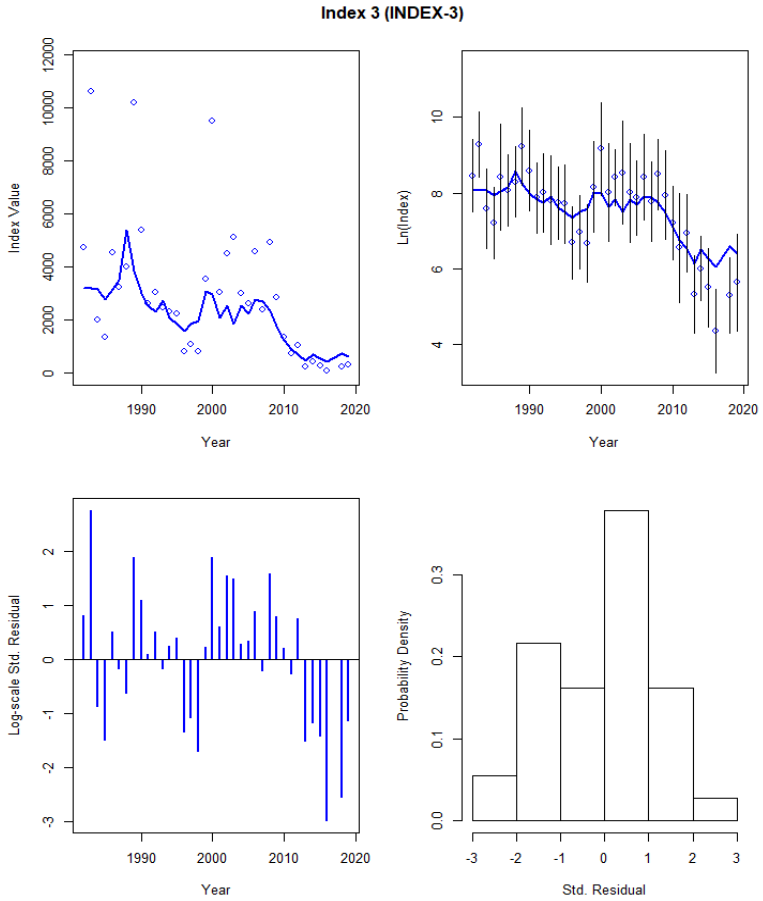
Model Diagnostics

- Model fits to survey indices (Spring MADMF)

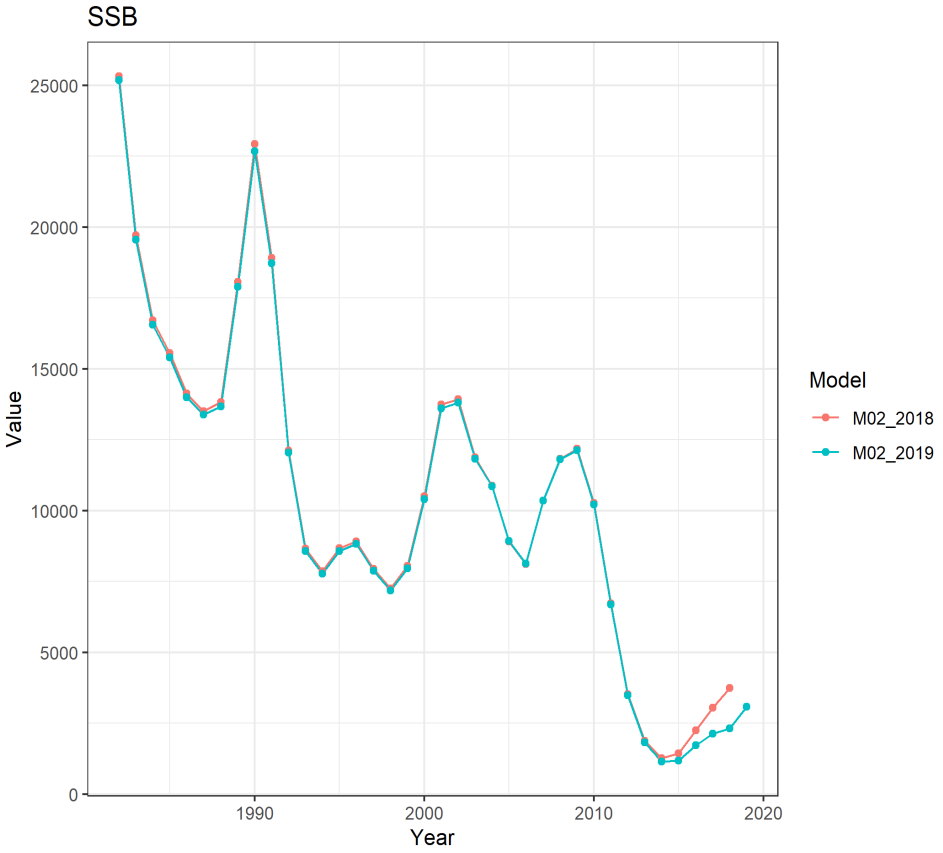
M=0.2

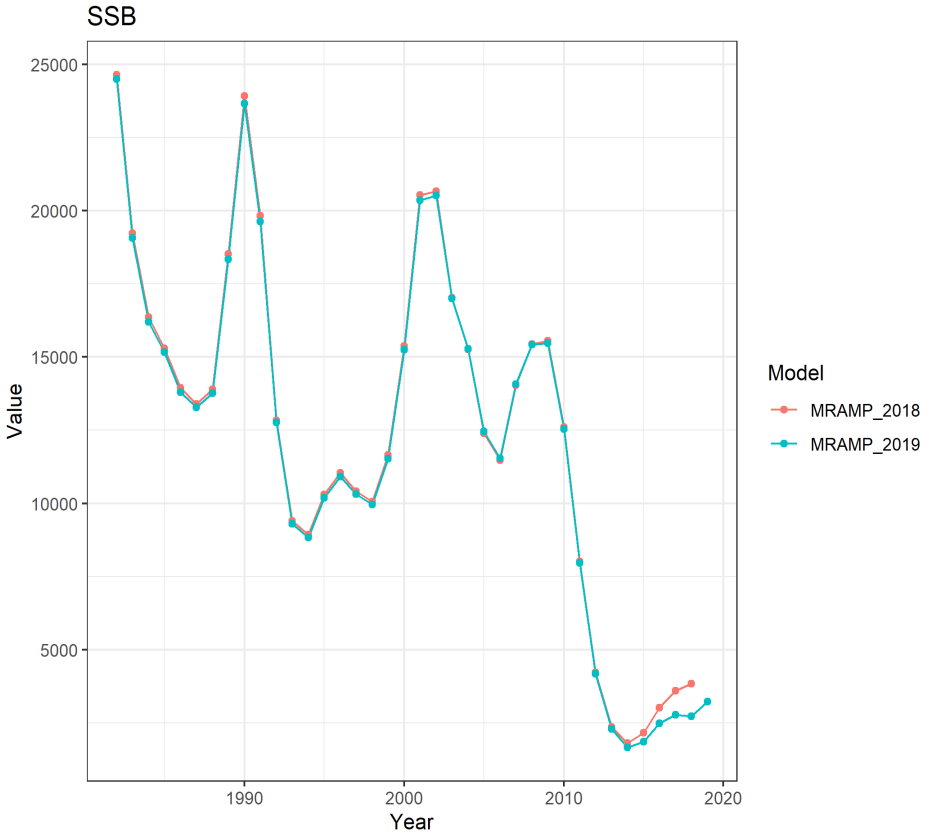


M-ramp



Model Results: comparison to last update





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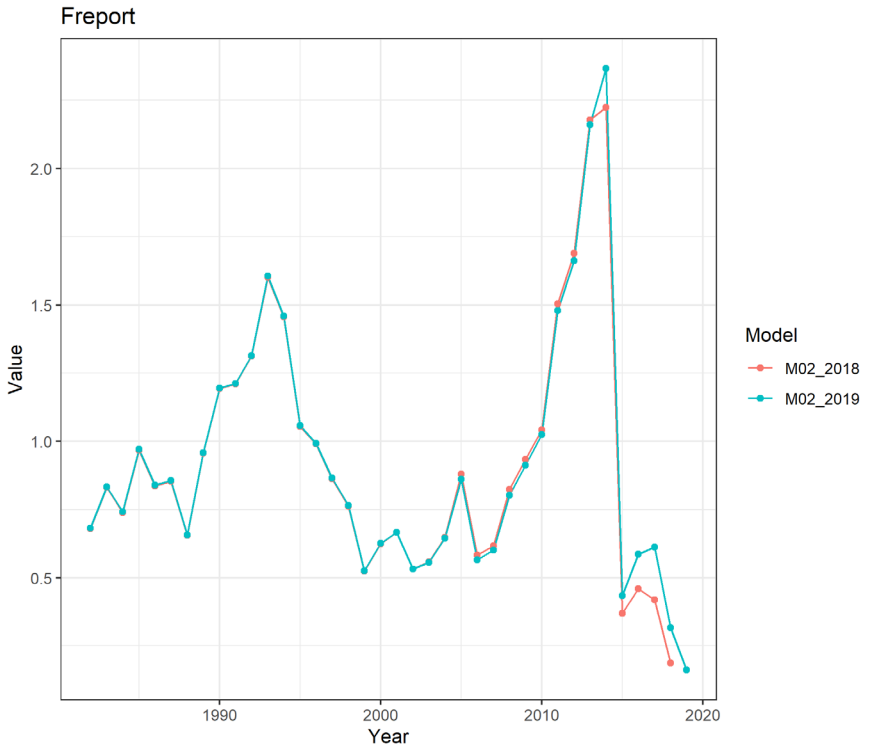
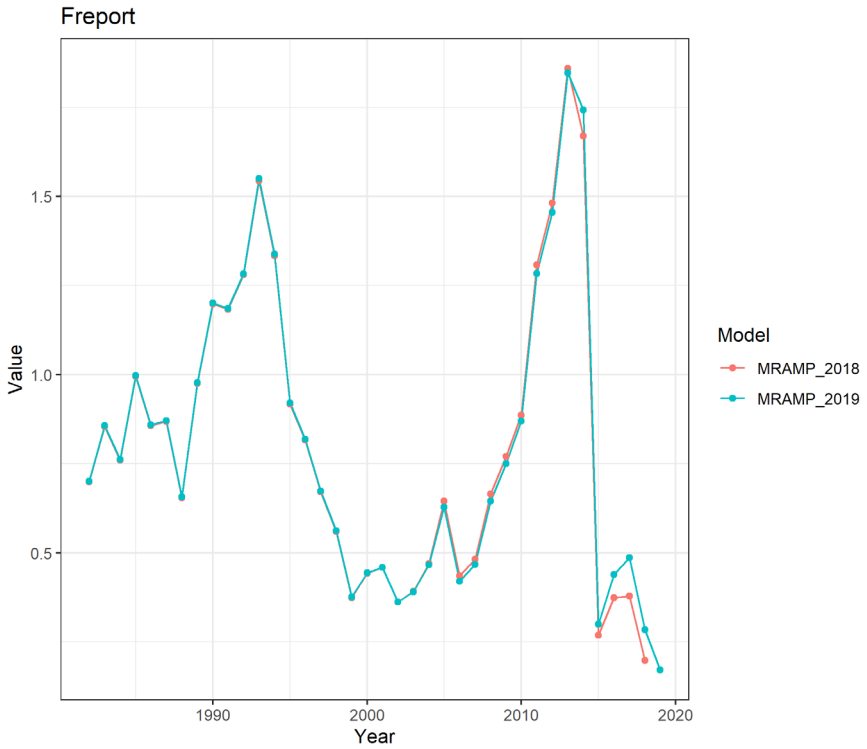
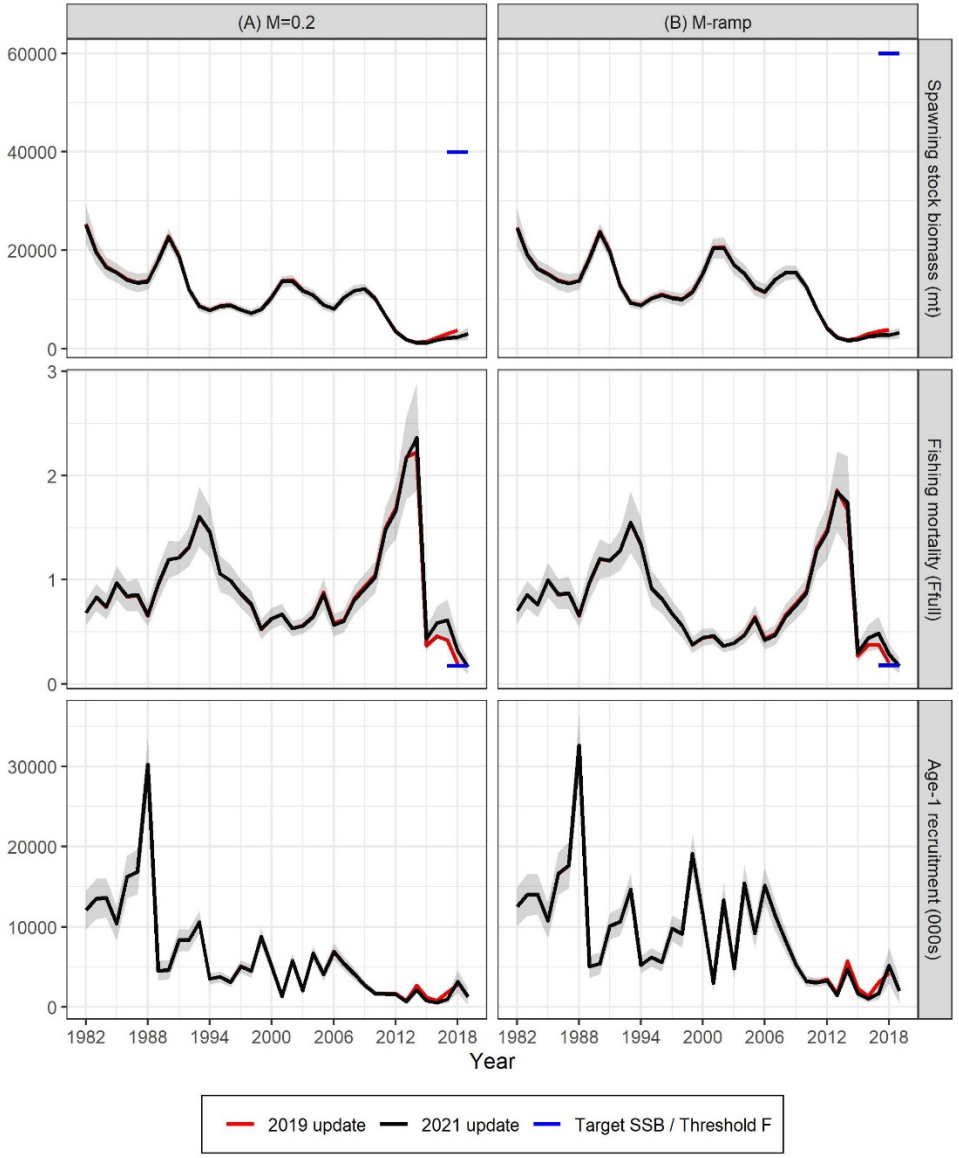




Model Results

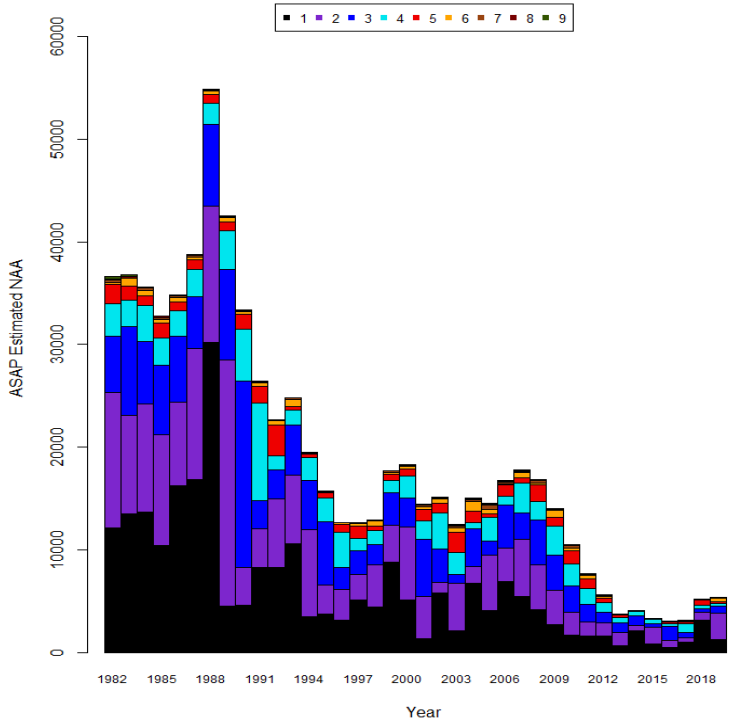
- Model results
  - 2021 update results are consistent with the 2019 update, but terminal year SSB has decreased compared to the 2019 update.
  - $SSB_{2019\ (terminal\ year)}$
    - M=0.2: 3,083 mt
    - M-ramp: 3,223 mt
  - $F_{2019\ (terminal\ year)}$
    - M=0.2: 0.162
    - M-ramp: 0.172
  - Recruitment
    - Continues to be low under both models



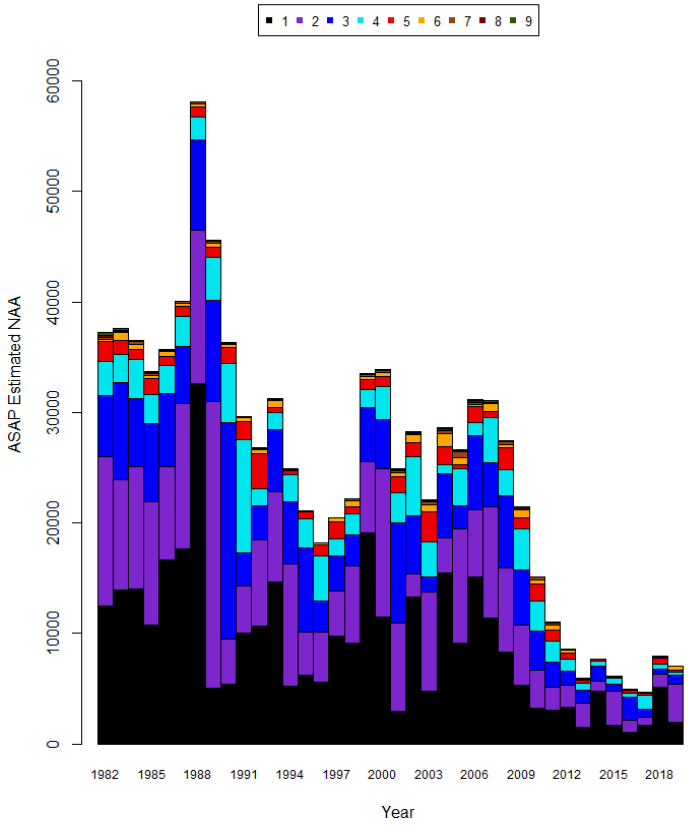
Model Results

- Numbers-at-age

M=0.2



M-ramp



Model Results

- Retrospective error (7-year peel)

M=0.2

Terminal year	Assessment	SSB	F
2012	SARC 55	0.47	-0.32
2013	2014 update	0.53	-0.33
2014	2015 update	0.54	-0.31
2016	2017 update	0.53	-0.31
2018	2019 MT	0.52	-0.29
2019	2021 MT	0.73	-0.35

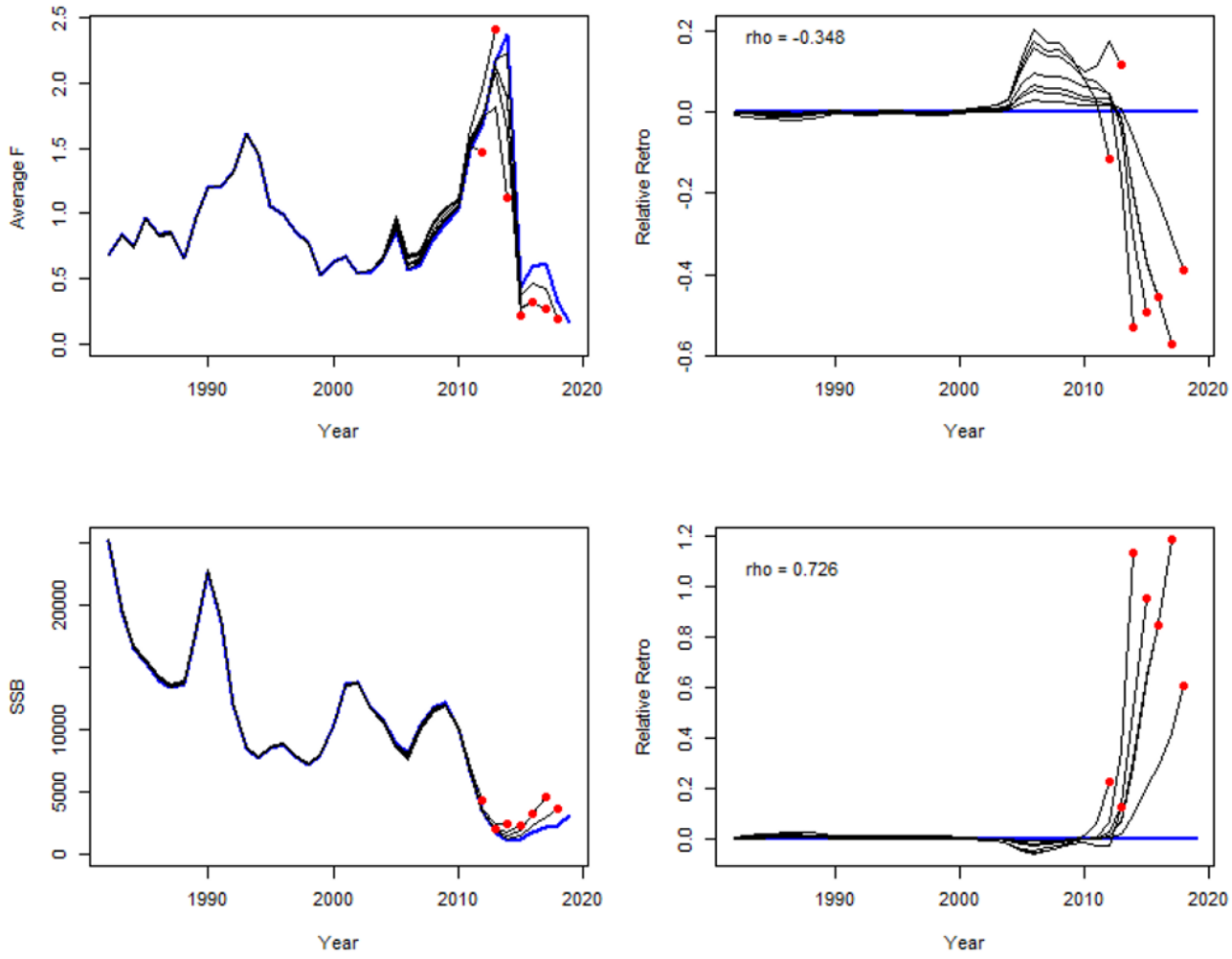
M-ramp

Terminal year	Assessment	SSB	F
2012	SARC 55	-0.01	0.04
2013	2014 update	0.17	-0.05
2014	2015 update	0.20	-0.08
2016	2017 update	0.30	-0.17
2018	2019 MT	0.29	-0.16
2019	2021 MT	0.42	-0.21

Model Results

- Retrospective error

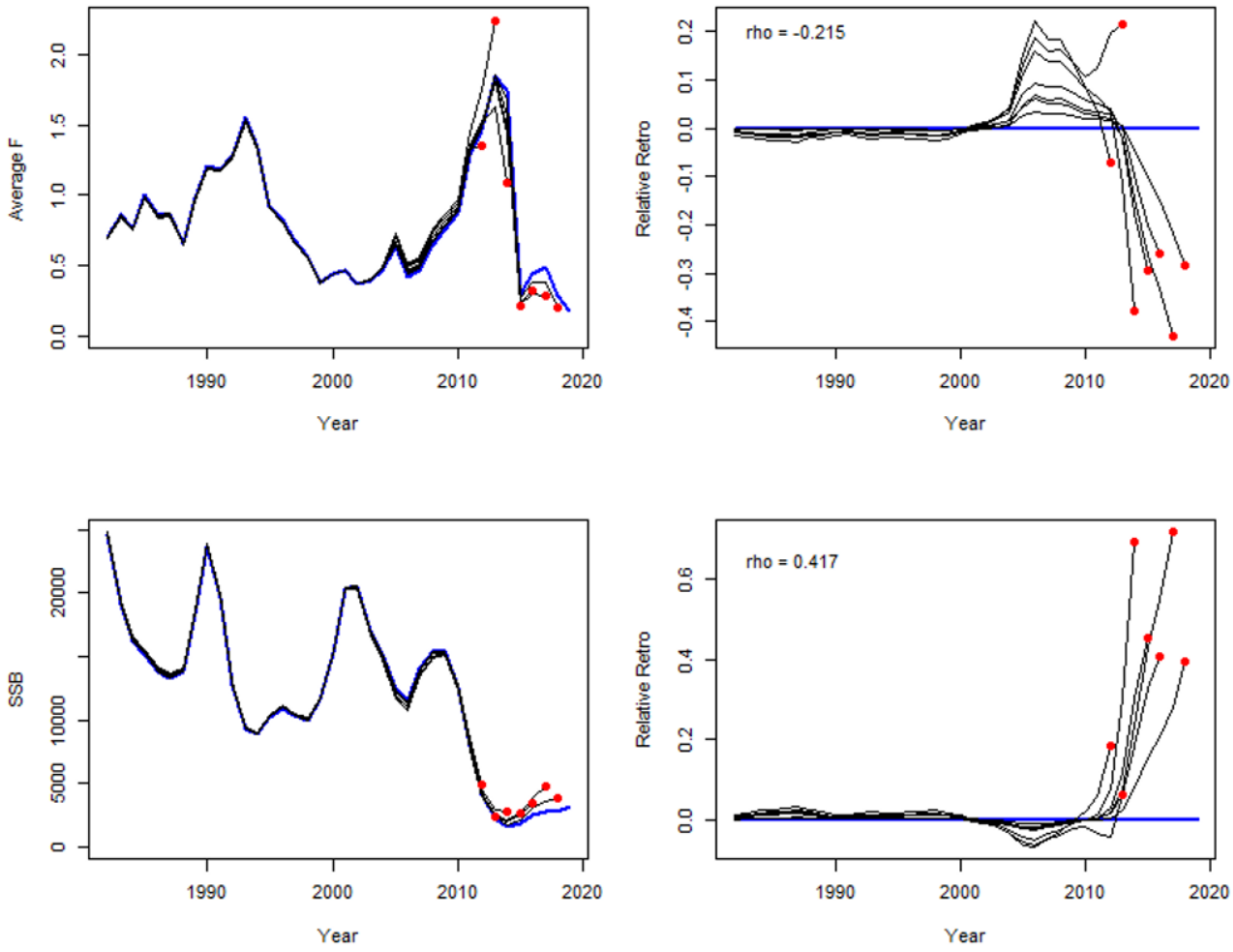
M=0.2



Model Results

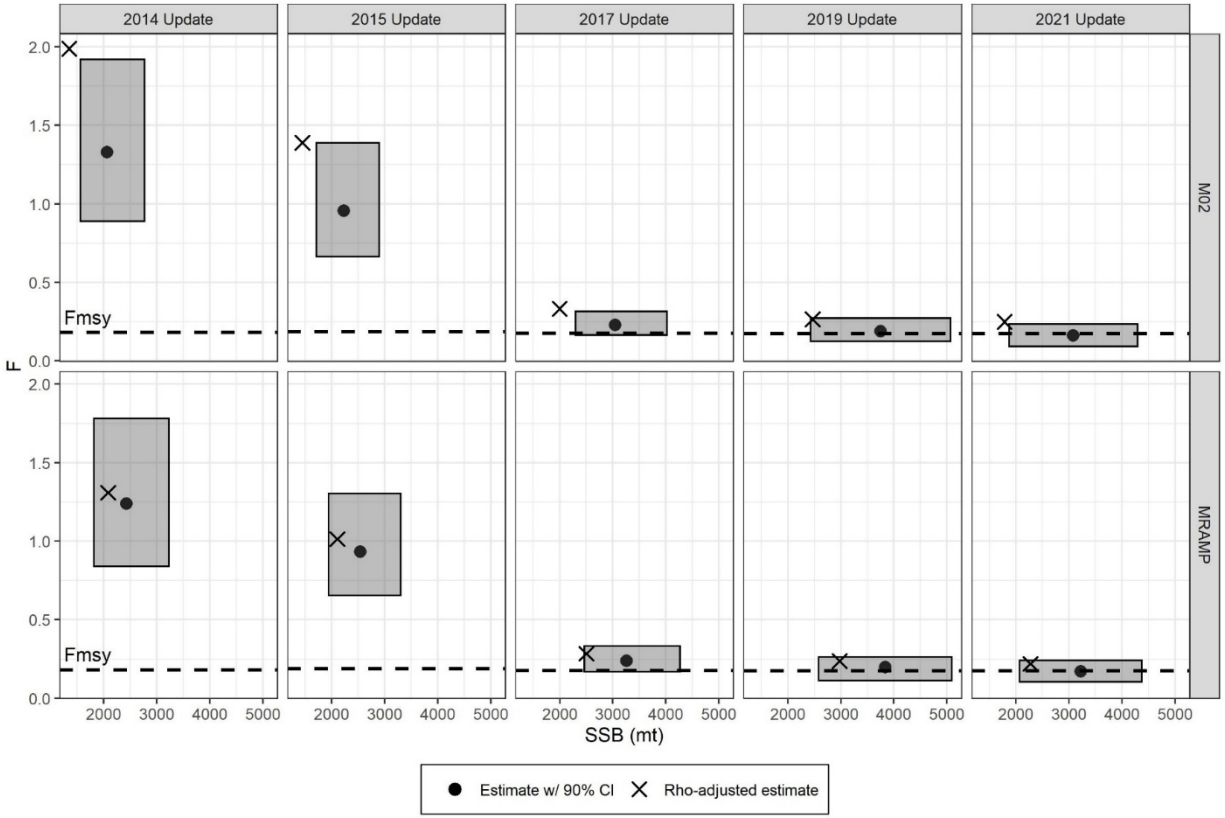
- Retrospective error

M-ramp



Model Results

- Retrospective error: M=0.2 – Major, M-Ramp – Minor

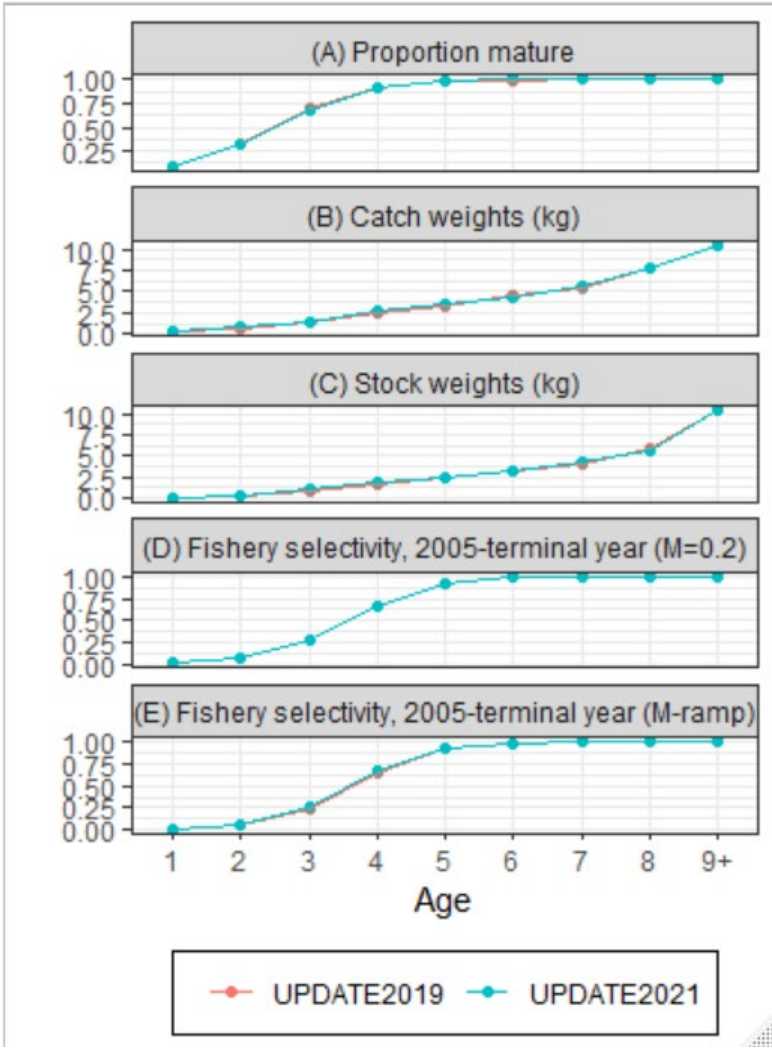


Model	Terminal year	Assessment	ssb.rho	f.rho	recr.rho	SSB	SSB_95_lo	SSB_95_hi	SSB_adjust	F	F_95_lo	F_95_hi	F_adjust
M=0.2	2019	2021 Update	0.726	-0.348	0.298	3083	1873	4293	1786	0.162	0.091	0.233	0.249
M-Ramp	2019	2021 Update	0.417	-0.215	0.025	3223	2073	4373	2275	0.172	0.103	0.241	0.219

Biological Reference Points (F_{MSY})

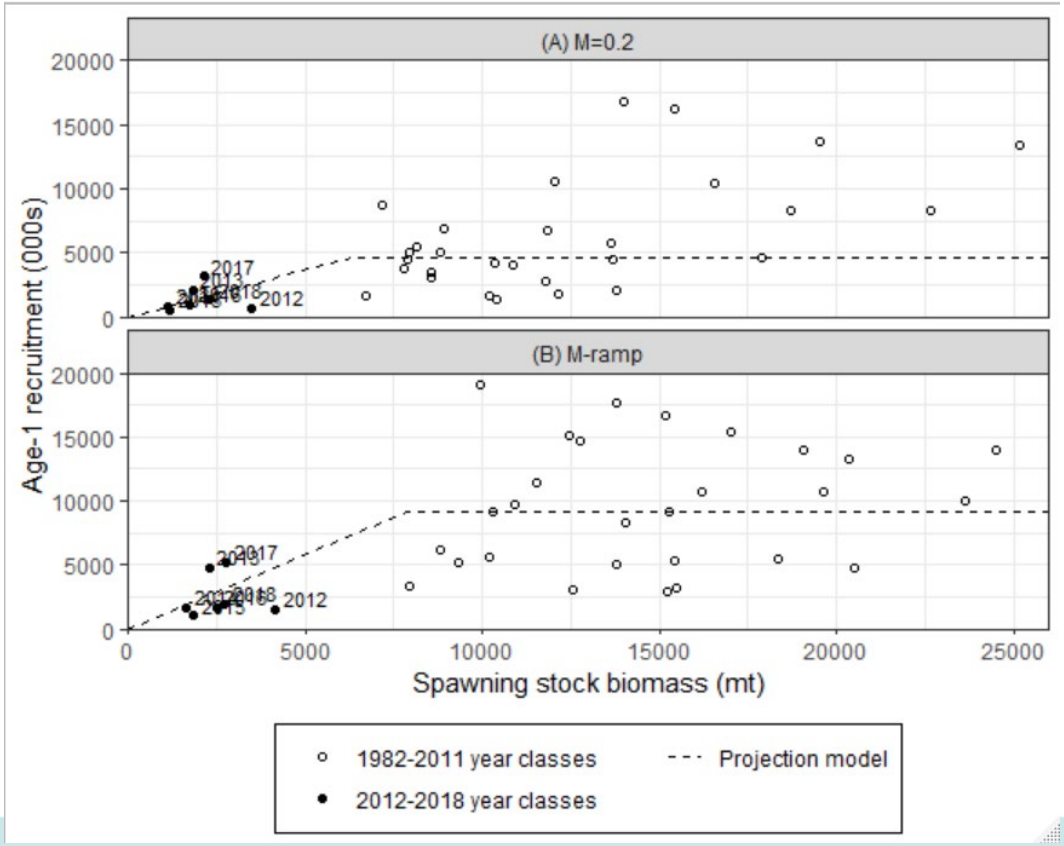
- Update $F_{40\%}$ F_{MSY} proxies
  - Natural mortality assumed equal to 0.2
  - Time series average maturity ogive
  - 3-year average of weights (2017-2019)
  - Last selectivity block (2004-2019)

Age	Natural mortality	Fraction mature	Jan1/SSB weights (kg)	Catch weights (kg)	Fishery selectivity (M = 0.2)	Fishery selectivity (M-ramp)
1	0.200	0.090	0.054	0.315	0.015	0.011
2	0.200	0.320	0.405	0.749	0.073	0.057
3	0.200	0.690	1.003	1.544	0.286	0.256
4	0.200	0.910	1.777	2.655	0.672	0.663
5	0.200	0.980	2.471	3.434	0.913	0.918
6	0.200	1.000	3.174	4.438	0.982	0.985
7	0.200	1.000	4.191	5.777	0.997	0.997
8	0.200	1.000	5.678	7.658	0.999	1.000
9^{+}	0.200	1.000	10.372	10.477	1.000	1.000



Biological Reference Points (SSB_{MSY})

- Update SSB_{MSY} proxies
  - Based on 100 year projections run at the F_{MSY} proxy
  - Projection model samples from CDF of recruitment from 1982-2017
    - When SSB is below a hinge point recruitment declines linearly to zero
      - M=0.2: 6,300 mt, M-ramp: 7,900 mt



Stock Status

- According to M=0.2 model, overfishing is occurring.
- According to M-ramp model, overfishing is not occurring, but it very close to the threshold.
- Both models indicate the stock is overfished.

Proxy reference points	**M=0.2 (retro-adjusted)**	**M-ramp**
$F_{full,\ 2019}$	0.249	0.172
F_{MSY}	0.173	0.175
$F_{full,\ 2019}/F_{MSY}$	1.44	0.98
Overfishing	**Yes**	**No**
SSB_{2019} (mt)	1,786	3,223
SSB_{MSY} (mt)	39,912	60,010
SSB_{2019}/SSB_{MSY}	0.04	0.05
Overfished	**Yes**	**Yes**
MSY (mt)	7,171	10,873
Median age1 recruitment (000s)	4,494	8,790

Short-term Projections

- Short-term projections chosen by the 2021 MT Review Panel:
  - M=0.2: retro-adjusted projection
  - M-ramp: M=0.4 short-term natural mortality

  - All projections run at F_{MSY}
  - Assumed 2020 & 2021 catch of 409 mt & 523 mt (*NEFMC PDT*)
  - 2021 catch is set to the total ACL

Year	Input	M=0.2 model			M-ramp model		
		Retrospective adjustment			M=0.4		
		Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}
2019	Model result	497	1,969	0.266	497	3,223	0.172
2020	Assumed catch	409	2,635	0.162	409	3,925	0.119
2021	Assumed catch	523	3,599	0.137	523	4,759	0.113
2022	Projection	821	4,508	0.173	892	5,254	0.175
2023	Projection	959	5,488	0.173	919	5,707	0.175
2024	Projection	1,244	7,279	0.173	1,071	6,802	0.175

Uncertainty

- Spring 2021 surveys show a decline in biomass, but they are not included in the model yet (NMFS spring 2021 biomass is the lowest on record)
- Accuracy of fishery removal estimates is an ongoing source of uncertainty (dealer misreporting, stock area reporting errors, observer effects)
- Natural mortality
  - Mostly impacts future productivity and rebuilding targets
- Stock structure
  - Ongoing process to determine new stock structure for the assessment
- Model diagnostics
  - Retrospective error
  - Over-estimation of survey indices in the latest year

Summary

- Consistent signals across data sources, models and approaches
- Fishery and survey data continue to show few old fish and few incoming recruits
- Survey indices and percent occurrence remain low
- Stock remains overfished
- Not clear whether overfishing status has changed

Questions?

Extra slides

Model Formulation

- Model formulation:
  - Years: 1982-2019
  - Fishery:
    - Single fleet (combined commercial and recreational)
    - CV = 0.05
    - Selectivity modelled with three selectivity blocks (all single logistic)
      - 1982-1988, 1989-2004, 2005-2019
  - Surveys:
    - CVs from surveys with re-weighting
      - NMFS spring:+0.2, NMFS fall:+0.1, MADMF spring:+0.3
    - Selectivity freely estimated at-age – fixed 6^{+} (NEFSC) and 1 (MADMF)
    - Catchability is estimated as a constant over time
  - Recruitment modelled as deviations from the mean
    - CV=0.5
  - Two models: M=0.2, M-ramp
    - M=0.2:1982-1988, ramp: 1989-2002, M=0.4: 2003-2019

Projections – Alternate recruitment assumption

Supplemental projections as requested by the 2021 Management Track Review Panel. These projections use recruitment observations from the most recent 15 years (2004 year class - 2018 year class). All other specifications are identical to the retro-adjusted M=0.2 model (left), and the M-ramp model with M=0.4 (right).

Year	Input	M=0.2 model (revised recruitment)			M-ramp model (revised recruitment)		
		Retrospective adjustment, last 15 yrs of recruitment			M=0.4, last 15 yrs of recruitment		
		Catch (mt)	Spawning stock biomass (mt)	F_{full}	Catch (mt)	Spawning stock biomass (mt)	F_{full}
2019	Model result	497	1,969	0.266	497	3,223	0.172
2020	Assumed catch	409	2,635	0.162	409	3,925	0.119
2021	Assumed catch	523	3,591	0.137	523	4,751	0.113
2022	Projection	809	4,346	0.173	882	5,066	0.175
2023	Projection	880	4,707	0.173	857	4,944	0.175
2024	Projection	966	5,237	0.173	852	5,021	0.175